

Shipboard Tests of the
Aquaworx ATC GmbH
Ballast Water Treatment System
AquaTriCombTM
for Type Approval according to Regulation D-2
and the relevant IMO Guideline (G8)

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Final report of the shipboard tests of the Aquaworx ATC GmbH
Ballast Water Treatment System
AquaTriCombTM
for Type Approval according to Regulation D-2 and the relevant IMO Guideline (G8)

(June 2010 - January 2011)

Shipboard tests onboard MV Timbus

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S. Gollasch 08-03-2011

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1. Introduction

The seven shipboard test cycles to test the performance of the AquaTriCombTM ballast water treatment system, developed by Aquaworx ATC GmbH, Munich, Germany, were undertaken on four voyages of the general cargo vessel *Timbus*, Rörd Braren Bereederungs-GmbH & Co KG, Kollmar, Germany, between June 2010 and January 2011. The vessel details and the dimensions of both test tanks (the control and treated tanks) are indicated in Table 1. The location of the test tanks is shown in Fig. 1.

Table 1. Main dimensions of the test vessel and tank details.

Vessel name	Timbus
IMO number	9198680
Vessel type	General cargo
Length overall	99.98 m
Dead Weight Tonnage (DWT)	6389 t
Total ballast water capacity	2558 m³
Number of ballast tanks	17
Number of ballast pumps	2
Capacity of ballast pumps	200 t/h
Number of ballast water	1
treatment systems installed	
Capacity of ballast water	250 m³/h
treatment system	
Control tank	03, double bottom, starboard
Control tank capacity	123 m³
Treated tank	Forepeak
Treated tank capacity	271 m³

The test ship is continuously operated on the route Terneuzen – Kiel Canal – Monsteras – Varberg – Karlshamn and one voyage usually stretches over ca. 1 week.

The AquaTriCombTM ballast water treatment system has a capacity to match the capacity of the vessel's ballast water pumps. The treatment system is installed in the engine room of the vessel. The treatment system is fully implemented and integrated into the ballast system of the vessel, but was only operated during the tests performed.

During the G8 test cycles both ballast water tanks, the control tank and the treated tank, were filled and emptied in sequence. All test cycles were undertaken by emptying and filling the tanks as much as possible.

All samples were taken during the entire ballast water uptake and discharge time. This approach most likely resulted in a more accurate organism density measurement

compared to just taking sub-samples during parts of the ballast water pumping operation (e.g. in the beginning, middle and end of the pumping time).

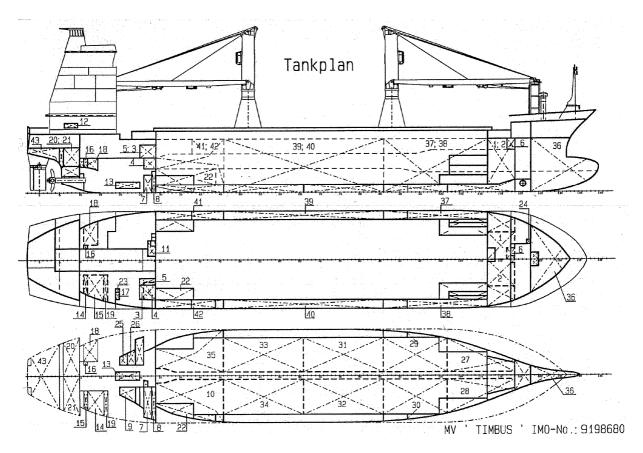


Figure 1 Tankplan of the test vessel *Timbus*. The tank used during the treated water experiments is the forepeak (Tank 36), tank 32 was used for the control experiments.

The ballast water was taken up in the following regions:

- Test cycle 1, off Falstebro/Ystad (Baltic Sea);
- Test cycle 2, off Texel (North Sea);
- Test cycle 3, during passage through the Kadettrinne (Baltic Sea);
- Test cycle 4, off Texel (North Sea);
- Test cycle 5, off Terneuzen (North Sea);
- Test cycle 6, off Texel (North Sea); and
- Test cycle 7, off Vlieland (North Sea).

The holding time of the ballast water in the tank between uptake and discharge was between ca. 12 hours (during test cycle one) and 24 hours (during test cycles 6 and 7 (Fig. 2)).

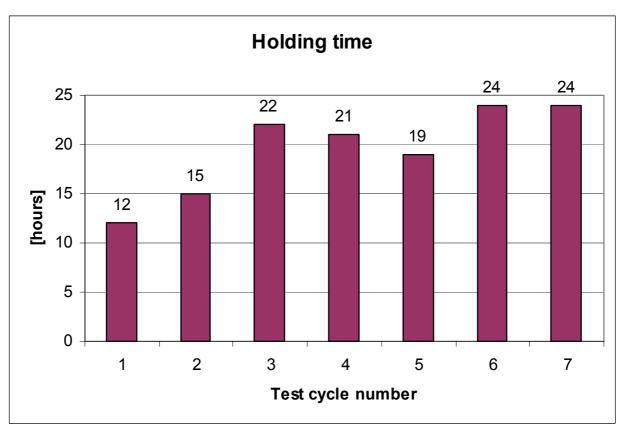


Figure 2. Approximate in-tank holding time of the ballast water between uptake and discharge during all seven test cycles.

During all test cycles all samples were taken by sampling team members of GoConsult, Hamburg, Germany.

2. Sampling scenario

During each test cycle samples were collected by using multiple HydroBios ballast water sampling kits in parallel and the samples were processed onboard as much as possible and as outlined in the onboard sampling protocol (Gollasch 2009). Plankton organisms larger than 50 micron in minimum dimension were analysed onboard directly after sampling. *E. coli* and *Enterococci* samples were prepared for incubation onboard directly after sampling and the incubation time was also completed onboard. Cholera bacteriae samples were prepared onboard for later analysis by IBEN, Bremerhaven, Germany. The samples for plankton above 10 micron and below 50 micron in minimum dimension and the phytoplankton below 10 micron in minimum dimension were analysed by NIOZ, Texel, The Netherlands. Procedures were followed according to the test protocol (Gollasch 2009) which was prepared in line with the most up-to-date version of the IMO Guideline G8 *Guidelines for the Approval of Ballast Water Management Systems* (IMO G8 2008).

The required number of samples and their volumes for one test cycle according to G8 are given in Table 2.

Table 2. Number of samples and their volumes for one test cycle according to G8.

Sample	Treated tank	Cont	trol tank
purpose	discharge	uptake	discharge
	(para 2.2.2.6.2 and	(para 2.2.2.6.1,	(para 2.2.2.6.1 and
	2.2.2.6.3)	2.2.2.6.3 and	2.2.2.6.3)
		2.2.2.9)	-
Environmental	1 sample	1 sample	1 sample
parameters ¹	(not required in G8)		(not required in G8)
>50 µm ²	3 x >1000 L	1 x >1000 L	1 x >1000 L
<50 to >10 µm	3 x >1 L	1 x >1 L	1 x >1 L
Bacteriae	3 x >500 ml	1 x >500 ml	1 x >500 ml
			(not required in G8)

The following samples were taken and processed in addition to the requirements of G8:

- Analysis of environmental and biological parameters of the uptake treated water;
- Analysis of environmental parameters of the discharged treated water;
- Analysis of environmental parameters of the discharged control water;
- Analysis of bacteriae of the discharged control water; and
- Analysis of phytoplankton organisms below 10 micron in minimum dimension.

¹ Temperature, salinity, total suspended solids and particulate organic carbon, see G8, Annex, Part 2, paragraph 2.2.2.9

² There is an inconsistency and unclear wording in G8 regarding the uptake sample of the treated line. G8, Annex, Part 2, paragraph 2.2.2.5 *Valid tests are indicated by uptake water, for both the control tank and ballast water to be treated, with viable organism concentration*... but 2.2.2.6 *Sampling regime* sets only requirements for the discharge of treated water. To be on the save side samples during uptake of the treated water are therefore taken and processed.

3. Results

The following tables show the results regarding environmental parameters and the biological analysis of the samples of all seven test cycles. It should be noted that more samples as required by G8 were taken and processed during all test cycles (see above).

Environmental parameters

The sample processing revealed environmental parameters as expected to occur in the ballast water uptake regions.

It should be noted that after completion of test cycle four the Bundesamt für Seeschifffahrt und Hydrographie, Hamburg, Germany, requested to measure the turbidity of the water during uptake and discharge tests as well as to document UV-sensor data. Due to the announcement of this request after test cycle four such data are only available for the test cycles performed thereafter, i.e. test cycles five to seven. The turbidity was measured by members of the GoConsult team by using a portable turbidimeter (Hach 2100P ISO Turbidimeter, Loveland, USA). The UV sensor data were provided by representatives of Aquaworx.

Biological results

The results show that the AquaTriComb[™] ballast water treatment system complied with the standards in Regulation D-2 for all tested organism groups during all tests of the treated water upon discharge.

The minimum intake concentrations of organisms for valid tests according to G8 were met in test cycles two to seven. In test cycle one the intake concentration of organisms below 50 and above 10 micron in minimum dimension was with 72 viable cells per 1 ml ca. 25% lower than the required minimum number of 90 viable cells per 1 ml. However, the minimum number of organisms above 50 micron in minimum dimension was in-line with the G8 requirements (see test cycle report below).

During all seven test cycles for all organism groups, including the phytoplankton organisms below 10 micron in minimum dimension, the D-2 standard was met at discharge of the treated water.

Date and time for ballast water **uptake**: 25.06.2010, 20.37 to 22.18

Position of ship during ballast water uptake ca. 55°15,2N / 013°20,5E (off Falstebro/Ystad).

- Distance travelled during uptake was ca. 13 nm.
- Water depth ca. 30 m.
- Distance to nearest main land ca. 4 nm.

Date and time for ballast water **discharge**: 26.06.2010, 10.37 to 12.19

Holding time of ballast water between uptake and discharge: approximately 12 hrs.

Table 3. Results of test cycle 1.

Damana atau	11!4	Ū	ptake w	ater	Discharge water						
Parameter	Unit	aantral	IMO	before	o o metro l	IMO	•	Treated	ł	aver.	IMO
		control	G8	treatment	control	G8	# 1	# 2	#3	#1-#3	G8
Temperature	°C	17.9	-	17.4	18.2	-	18.2	18.2	18.2	-	-
Salinity	PSU	12.3	-	12.3	12.2	-	12.4	12.4	12.4	-	-
POC *	mg/l	2.1	-	2.6	2.5	-	1.7	1.5	1.2	-	-
TSS *	mg/l	2.0	-	4.5	8.6	-	2.5	1.8	2.0	-	-
Sample vol. >50 µm	Litres	1535	>1000	1694	1783	>1000	1698	1710	1684	-	>1000
Sample vol. 50-10 µm	Litres	5	>1	5	5	>1	5	5	5	ı	>1
Sample vol. bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5
Organisms >50µm	org./1m³	1042	>90	1275	1219	>10	0.0	5.8	0.0	1.9	<10
Organisms 10- 50µm*	org./1ml	72	>90	57	61	>10	0.0	0.0	0.0	0.0	<10
Organisms 6-7µm*	org./1ml	1339	-	1116	891	-	0.0	0.0	0.0	0.0	-
Organisms ca. 4 µm*	org./1ml	7097	-	6397	8969	-	0.0	0.0	0.0	0.0	-
Escherichia coli	cfu/100ml	0.0	-	0.0	0.0	-	0.0	0.0	0.0	0.0	<250
Intestinal Enterococci	cfu/100ml	3.0	-	0.0	0.0	-	0.0	0.0	0.0	0.0	<100
Vibrio cholerae**	cfu/100ml	0.0	-	0.0	0.0	-	0.0	0.0	0.0	0.0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Date and time for ballast water **uptake**: 24.09.2010, 14.10 to 17.10

Position of ship during start of ballast water uptake ca. 53°09.8N / 004°31.0E (off Texel).

- Distance travelled during uptake was ca. 45 nm.
- Water depth ca. 20 to 25 m.
- Distance to nearest main land ca. 10 nm.

Date and time for ballast water **discharge**: 25.09.2010, 8.27 to 9.57

Holding time of ballast water between uptake and discharge: approximately 15 hrs.

Table 4. Results of test cycle 2.

Damana atau	11!4	U	ptake w	ater	Discharge water						
Parameter	Unit	4 1	IMO	before	0	IMO	-	Treated	t	aver.	IMO
		control	G8	treatment	Control	G8	# 1	# 2	# 3	#1-#3	G8
Temperature	°C	16.6	-	16.2	16.2	-	16.1	16.1	16.1	-	-
Salinity	PSU	32.4	-	32.1	32.0	-	32.2	32.2	32.2	-	-
POC *	mg/l	3.7	-	3.7	4.7	-	3.0	3.9	3.5	-	-
TSS *	mg/l	8.2	-	8.8	11.6	-	7.7	8.5	8.2	-	-
Sample vol. >50 µm	Litres	1564	>1000	1946	1403	>1000	1420	1427	1314	-	>1000
Sample vol. 50-10 µm	Litres	5	>1	5	5	>1	5	5	5	-	>1
Sample vol. bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5
Organisms >50µm	org./1m³	1586	>90	1199	1273	>10	0.0	0.0	2.5	0.8	<10
Organisms 10- 50µm*	org./1ml	386	>90	765	360	>10	0.0	0.0	0.0	0.0	<10
Organisms 6-7µm*	org./1ml	1269	-	1500	1905	-	0.0	0.0	0.0	0.0	-
Organisms ca. 4 µm*	org./1ml	5826	-	4358	5291	-	0.0	0.0	0.0	0.0	-
Escherichia coli	cfu/100ml	24.0	-	4.0	6.0	-	0.0	0.0	0.0	0.0	<250
Intestinal Enterococci	cfu/100ml	50.0	-	30.0	80.0	-	30.0	8.0	0.0	12.7	<100
Vibrio cholerae**	cfu/100ml	0.0	-	0.0	0.0	-	0.0	0.0	0.0	0.0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Date and time for ballast water **uptake**: 25.09.2010, 16.16 to 18.55

Position of ship during start of ballast water uptake ca. 54°24.5N / 012°04.8E (Kadettrinne).

- Distance travelled during uptake was ca. 37 nm.
- Water depth ca. 12 to 24 m.
- Distance to nearest main land ca. 6 nm.

Date and time for ballast water **discharge**: 26.09.2010, 14.48 to 16.25

Holding time of ballast water between uptake and discharge: approximately 22 hrs.

Table 5. Results of test cycle 3.

Damana atau	11!4	U	ptake w	ater	Discharge water						
Parameter	Unit	control	IMO	before	Control	IMO	-	Treated	t	aver.	IMO
		control	G8	treatment	Control	G8	# 1	# 2	# 3	#1-#3	G8
Temperature	°C	14.6	-	13.7	14.0	-	14.0	14.0	14.0	-	-
Salinity	PSU	9.8	-	7.3	9.1	-	7.4	7.4	7.4	-	-
POC *	mg/l	1.4	-	2.0	8.0	-	5.1	7.4	9.5	-	-
TSS *	mg/l	2.8	-	2.5	45.8	-	24.8	42.6	58.8	-	-
Sample vol. >50 µm	Litres	1183	>1000	1526	1170	>1000	1357	1410	1452	-	>1000
Sample vol. 50-10 µm	Litres	5	>1	5	5	>1	5	5	5	-	>1
Sample vol. bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5
Organisms >50µm	org./1m³	4351	>90	2348	1436	>10	0.0	0.0	0.0	0.0	<10
Organisms 10- 50µm*	org./1ml	315	>90	121	451	>10	0.0	0.0	0.0	0.0	<10
Organisms 6-7µm*	org./1ml	4467	-	2985	3720	-	0.0	0.0	0.0	0.0	-
Organisms ca. 4 µm*	org./1ml	48901	-	41181	35465	-	0.0	0.0	0.0	0.0	-
Escherichia coli	cfu/100ml	0.0	-	0.0	70	-	70.0	50.0	0.0	40.0	<250
Intestinal Enterococci	cfu/100ml	40.0	-	10	80	-	2.0	80.0	0.0	27.3	<100
Vibrio cholerae**	cfu/100ml	0.0	-	0.0		-	0.0	0.0	0.0	0.0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Date and time for ballast water **uptake**: 30.09.2010, 09.22 to 11.21

Position of ship during start of ballast water uptake ca. 53°09.8N / 004°31.0E (off Texel).

- Distance travelled during uptake was ca. 28 nm.
- Water depth ca. 20 to 25 m.
- Distance to nearest main land ca. 15 nm.

Date and time for ballast water **discharge**: 01.10.2010, 06.33 to 08.05

Holding time of ballast water between uptake and discharge: approximately 21 hrs.

Table 6. Results of test cycle 4.

Damana atau	1124	U	ptake w	ater	Discharge water						
Parameter	Unit	control	IMO	before	Control	IMO	-	Treated	t	aver.	IMO
		control	G8	treatment	Control	G8	# 1	# 2	# 3	#1-#3	G8
Temperature	°C	15.9	-	15.7	13.2	-	13.8	13.8	13.8	-	-
Salinity	PSU	33.1	-	31.0	32.5	1	31.6	31.6	31.6	-	-
POC *	mg/l	5.8	-	3.8	4.0	-	3.7	3.6	4.0	-	-
TSS *	mg/l	10.0	-	7.3	9.8	-	9.6	10.5	11.7	-	-
Sample vol. >50 µm	Litres	1504	>1000	1604	1720	>1000	2119	2184	2027	-	>1000
Sample vol. 50-10 µm	Litres	5	>1	5	5	>1	5	5	5	-	>1
Sample vol. bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5
Organisms >50µm	org./1m³	3457	>90	2816	1250	>10	0.0	0.0	0.0	0.0	<10
Organisms 10- 50µm*	org./1ml	201	>90	199	143	>10	0.0	0.0	0.0	0.0	<10
Organisms 6-7µm*	org./1ml	1340	-	1135	1178	ı	0.0	0.0	0.0	0.0	-
Organisms ca. 4 µm*	org./1ml	5605	1	4017	5211	ı	0.0	0.0	0.0	0.0	-
Escherichia coli	cfu/100ml	13.0	-	0.0	0.0	-	0.0	0.0	0.0	0.0	<250
Intestinal Enterococci	cfu/100ml	14.0	-	11	0.0	1	0.0	0.0	0.0	0.0	<100
Vibrio cholerae**	cfu/100ml	0.0	-	0.0	0.0	-	0.0	0.0	0.0	0.0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Date and time for ballast water **uptake**: 10.10.2010, 14.56 to 17.13

Position of ship during start of ballast water uptake: 51°41.4N / 003°37.1E (off Terneuzen).

- Distance travelled during uptake was ca. 19 nm.
- Water depth ca. 8 to 12 m.
- Distance to nearest main land ca. 0.5 nm.

Date and time for ballast water **discharge**: 11.10.2010, 10.00 to 11.40

Holding time of ballast water between uptake and discharge: approximately 19 hrs.

Table 7A. Results of test cycle 5.

Dawamatan	11:4	U	ptake w	vater	Discharge water						
Parameter	Unit	o o netwo l	IMO	before	Control	IMO	Treated			aver.	IMO
		control	G8	treatment	Control	G8	# 1	# 2	# 3	#1-#3	G8
Temperature	°C	16.1	-	16.5	16.1	-	16.0	16.0	16.0	-	-
Salinity	PSU	32.1	-	33.9	31.5	-	33.8	33.8	33.8	-	-
POC *	mg/l	4.1	-	4.9	4.3	-	4.8	5.1	5.0	-	-
TSS *	mg/l	10.4	-	8.9	12.5	-	10.1	10.0	10.1	-	-
Sample vol. >50 μm	Litres	1440	>100 0	1647	1225	>1000	1806	1824	1762	-	>1000
Sample vol. 50-10 µm	Litres	5	>1	5	5	>1	5	5	5	-	>1
Sample vol. bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5
Organisms >50µm	org./1m³	10069	>90	3957	7810	>10	0.0	0.0	0.0	0.0	<10
Organisms 10- 50µm*	org./1ml	219	>90	142	270	>10	0.0	0.0	0.0	0.0	<10
Organisms 6-7µm*	org./1ml	673	-	638	395	-	0.0	0.0	0.0	0.0	-
Organisms ca. 4 µm*	org./1ml	4878	-	13564	4967	-	0.0	0.0	0.0	0.0	-
Escherichia coli	cfu/100ml	42.0	-	0.0	13.0	-	1.0	0.0	0.0	0.3	<250
Intestinal Enterococci	cfu/100ml	3.0	-	2.0	2.0	-	3.0	0.0	0.0	1.0	<100
Vibrio cholerae**	cfu/100ml	0.0	-	0.0	0.0	-	0.0	0.0	0.0	0.0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Table 7B. Turbidity measurements during test cycle 5.

Doromotor	I I mid	Uptake water			Discharge water						
Parameter	Unit	control	IMO	before	Control	, IMO	Treated			aver.	IMO
		G8	treatment	Control	G8	# 1	# 2	#3	#1-#3	G8	
Turbidity	FNU	10.2	-	2.5	17.2	-	4.1	3.4	4.2	-	-

Table 7C. UV sensor data during test cycle 5.

Test cycle 5	Date	Time	# 1 [W/m²]	# 2 [W/m²]	# 3 [W/m²]	Mean [W/m²]
Uptake *	10.10.2010	14:56 – 17:13	395	403,1	405,4	401,2
Discharge *	11.10.2010	10:00 - 11:40	404,8	404,9	402,4	404,0

Remark: For control water UV sensor values cannot be reported, because control water does not pass through the ballast water treatment system.

^{*} provided by representatives of Aquaworx.

Date and time for ballast water **uptake**: 15.10.2010, 09.28 to 11.48

Position of ship during start of ballast water uptake: 52°45.2N / 004°03.6E (off Texel).

- Distance travelled during uptake was ca. 21 nm.
- Water depth ca. 20 to 26 m.
- Distance to nearest main land ca. 15 nm.

Date and time for ballast water **discharge**: 16.10.2010, 09.57 to 11.45

Holding time of ballast water between uptake and discharge: approximately 24 hrs.

Table 8A. Results of test cycle 6.

Dawamatan	11-0:4	U	ptake w	vater	Discharge water						
Parameter	Unit	o o netwo l	IMO	before	Control	IMO	-	Treated	i	aver.	IMO
		control	G8	treatment	Control	G8	# 1	# 2	# 3	#1-#3	G8
Temperature	°C	15.4	-	15.2	14.4	-	14.2	14.2	14.2	-	-
Salinity	PSU	33.4	-	32.8	32.8	-	31.8	31.8	31.8	-	-
POC *	mg/l	5.0	-	5.2	3.8	-	3.3	3.2	2.3	-	-
TSS *	mg/l	9.9	-	7.8	12.6	-	9.2	9.2	6.6	-	-
Sample vol. >50 µm	Litres	1342	>100 0	1544	1578	>1000	1322	1547	1548	-	>1000
Sample vol. 50-10 µm	Litres	6	>1	6	8	>1	8	8	8	-	>1
Sample vol. bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5
Organisms >50µm	org./1m³	4086	>90	3120	3813	>10	0.0	0.0	0.0	0.0	<10
Organisms 10- 50µm*	org./1ml	104	>90	133	193	>10	0.0	0.0	0.0	0.0	<10
Organisms 6-7µm*	org./1ml	1319	-	1838	347	-	0.0	0.0	0.0	0.0	-
Organisms ca. 4 µm*	org./1ml	14459	-	12509	8260	-	0.0	0.0	0.0	0.0	-
Escherichia coli	cfu/100ml	0.0	-	17.0	2.0	-	0.0	0.0	0.0	0.0	<250
Intestinal Enterococci	cfu/100ml	4.0	-	5.0	20.0	-	8.0	1.0	2.0	3.7	<100
Vibrio cholerae**	cfu/100ml	0.0	-	0.0	0.0	ı	0.0	0.0	0.0	0.0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Table 8B. Turbidity measurements during test cycle 6.

Davamatar	Unit	Uptake water			Discharge water						
Parameter		control	IMO		Control	IMO	Treated			aver.	OMI
		Control	G8	treatment	Control	G8	# 1	# 2	#3	#1-#3	G8
Turbidity	FNU	2.3	-	1.8	9.7	-	3.7	3.3	3.7	-	-

Table 8C. UV sensor data during test cycle 6.

Test cycle 6	Date	Time	# 1	# 2	#3	Mean
_			[W/m ²]	[W/m ²]	[W/m ²]	[W/m ²]
Uptake *	15.10.2010	09:28 - 11:48	415,3	396,6	371,5	394,5
Discharge *	16.10.2010	09:57 - 11:45	396,2	392,8	386,2	391,7

Remark: For control water UV sensor values cannot be reported, because control water does not pass through the ballast water treatment system.

^{*} provided by representatives of Aquaworx.

Date and time for ballast water **uptake**: 15.01.2011, 13.40 to 15.36

Position of ship during start of ballast water uptake: 53°36.2N / 004°85.4E (off Vlieland).

- Distance travelled during uptake was ca. 32 nm.
- Water depth ca. 20 m.
- Distance to nearest main land ca. 20 nm.

Date and time for ballast water <u>discharge</u>: 16.01.2011, 13.20 to 14.52

Holding time of ballast water between uptake and discharge: approximately 24 hrs.

Table 9A. Results of test cycle 7.

Damana atau	Unit	Uptake water			Discharge water						
Parameter		tuel	IMO before	Control	IMO	Treated			aver.	IMO	
		control	G8	treatment	Control	G8	# 1	# 2	# 3	#1-#3	G8
Temperature	°C	5.0	-	4.4	30.8	-	3.5	3.5	3.5	-	-
Salinity	PSU	31.3	-	30.1	3.8	-	30.9	30.9	30.9	-	-
POC *	mg/l	6.4	-	5.0	4.9	-	6.8	6.3	5.4	-	-
TSS *	mg/l	19.5	-	20.9	25.4	-	25.2	27.0	24.3	-	-
Sample vol. >50 µm	Litres	1430	>1000	1779	1401	>1000	1866	1825	1853	-	>1000
Sample vol. 50-10 µm	Litres	6	>1	6	6	>1	6	6	6	-	>1
Sample vol. bacteria	Litres	1	>0,5	1	1	-	1	1	1	-	>0,5
Organisms >50µm	org./1m³	914	>90	1297	466	>10	0.0	0.0	0.0	0.0	<10
Organisms 10- 50µm*	org./1ml	193	>90	175	354	>10	0.0	0.0	0.0	0.0	<10
Organisms 6-7µm*	org./1ml	452	-	321	478	-	0.0	0.0	0.0	0.0	-
Organisms ca. 4 µm*	org./1ml	1777	-	1322	2317	-	0.0	0.0	0.0	0.0	-
Escherichia coli	cfu/100ml	15.0	-	0.0	8.0	-	0.0	0.0	0.0	0.0	<250
Intestinal Enterococci	cfu/100ml	23.0	-	17.0	12.0	-	0.0	0.0	0.0	0.0	<100
Vibrio cholerae**	cfu/100ml	0.0	-	0.0	0.0	-	0.0	0.0	0.0	0.0	<1

^{*} Samples analysed at NIOZ, Texel. ** Samples analysed at IBEN, Bremerhaven.

Table 9B. Turbidity measurements during test cycle 7.

Parameter	I I m i 4	Uptake water			Discharge water						
	Unit	CONTROL		before	Control	IMO G8	Treated		aver.	IMO	
				treatment			# 1	# 2	# 3	#1-#3	G8
Turbidity	FNU	3.3	-	4.8	7.8	-	7.4	9.7	8.4	-	-

Table 9C. UV sensor data during test cycle 7.

Test cycle 7	Date	Time	# 1 [W/m²]	# 2 [W/m²]	# 3 [W/m²]	Mean [W/m²]
Uptake *	15.01.2011	13:40 – 15:36	403,2	400,8	402,0	402,0
Discharge *	16.01.2011	13:20 - 14:52	387,9	383,6	380,6	384,0

Remark: For control water UV sensor values cannot be reported, because control water does not pass through the ballast water treatment system.

^{*} provided by representatives of Aquaworx.

4. Discussion of the results

The AquaTriCombTM ballast water treatment system has been thoroughly tested during the four test voyages on which seven test cycles were performed between June 2010 and January 2011 in different environmental conditions and during different seasons. During these tests the system has proven to be seaworthy and highly effective to treat organisms.

During all onboard tests, sample taking and sample processing was undertaken as previously outlined in the sampling protocol (Gollasch 2009).

It is remarkable that during all seven test cycles the treated water at discharge contained no living phytoplankton organisms of the organism groups below 50 micron in minimum dimension addressed in Regulation D-2 of the IMO Ballast Water Management Convention (2004). Only during test cycles one and two living organisms greater than or equal to 50 micron in minimum dimension were found in the discharge of the treated water with numbers of less than 2 per cubic metre. In all other tests no living organisms in this size class were found in the discharge of the treated water.

Although this report focuses on the organism groups as described in Regulation D-2 it should also be noted that in the size class below 10 micron in minimum dimension no living phytoplankton was observed in the treated water at discharge.

The bacteria found in the discharge samples of the treated water may have occurred due to contamination of the work onboard rather than as a lack of the treatment system performance. However, this is difficult to proof in retrospect. No laboratory facility was available on this commercial vessel and the bacteria processing was undertaken in usual crew cabins. All contamination precautions possible and as outlined in the sampling protocol were taken, but the nearby washroom as well we the lack of a sterile working environment likely resulted in a bacteria contamination risk.

5. Test validity

The required organism intake concentrations to challenge the treatment system were met and exceeded in six of the seven test cycles. In Test cycle one the intake concentration of organisms below 50 and above 10 micron in minimum dimension was not met (see above report of test cycle 1).

The D-2 Standard, as described in the IMO Ballast Water Management Convention of 2004, was met at discharge of the treated water in all seven test cycles. Further, the minimum water volumes of all sample types, as stated in G8, were met.

References

Gollasch, S. 2009. Onboard Sampling Protocol to Test the Efficiency of the Ballast Water Treatment System developed by Aquaworx ATC GmbH, Munich, Germany, Version 8, 2009-03-02, 44 pp.

IMO G8 2008. IMO Guideline G8 Guidelines for the Approval of Ballast Water Management Systems adopted on 10 October 2008 as Resolution MEPC.174(58), 28 pp.

Appendix 1 Statement regarding Ship-board Tests

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Statement regarding Shipboard-Tests of the Aquaworx ATC GmbH AquaTriCombTM Ballast Water Treatment System

24-01-2011

To whom it may concern

This is to confirm that the shipboard tests of the AquaTriCombTM ballast water treatment system, developed by Aquaworx ATC GmbH, Munich, Germany, as documented in

Final Report, Shipboard Tests of the Aquaworx ATC GmbH Ballast Water Treatment System AquaTriCombTM for Type Approval according to Regulation D-2 and the relevant IMO Guideline (G8) [the document this statement is appended to]

were undertaken according to the

Onboard Sampling Protocol to Test the Efficiency of the AquaTriCombTM Ballast Water Treatment System developed by Aquaworx ATC GmbH, Munich, Germany, Version 8, 2009-03-02, 44 pp.

which was evaluated and approved by the Bundesamt für Seeschifffahrt und Hydrographie, Hamburg prior to the tests.

Kind regards,

S. Gollasch

Senior scientist, GoConsult